Memo

To: Craig Zeller, Remedial Project Manager,
U.S. Environmental Protection Agency

October 26, 2016

From: Amec Foster Wheeler Environment & Infrastructure, Inc.

CC: Gerald Pouncey, Morris, Manning & Martin, LLP
Heather Friedman, Morris, Manning & Martin, LLP

Ref: Koppers Charleston NPL Site, Technical Impracticability Waiver Proposal

Re: Revised ISS Treatment Zone and Modeling Parameters – Supporting Model Documentation

As transmitted to you via email on October 11, 2016, Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) provided a memorandum summarizing the results of numerous adjustments to the fate and transport model provided in the TI Waiver Demonstration Report for the subject site. These adjustments were performed to address EPA's September 1, 2016 proposal, and included requests to:

1. Expand the proposed ISS treatment area in the Old Impoundment Area (resulting in an overall 32% increase in treatment volume);
2. Lower the initial benzene concentration as a model input parameter issue; and
3. Re-run the model with the expanded treatment areas and adjusted benzene input parameter.

The attached supporting model documentation is provided to further explain and depict the supplemental fate and transport model results that were prepared consistent with various assumptions regarding input parameters, and additional model permutations.

The attached model scenarios are in recognition of EPA's concern about the original dissolved concentrations assumed for benzene in the Old Impoundment ISS Area (initially 5,000 ppb, lowered to 2,000 ppb during sensitivity analyses evaluation and alternative model calibration). EPA requested that these values be lowered further, despite the fact that site data, referenced literature values and downgradient results supported use of 2,000 ppb concentration. Consequently, Amec Foster Wheeler has prepared model runs assuming benzene concentrations of 1,000 and 500 ppb, and benzene plume depictions are provided based on these revised concentrations and varying other fate and transport model parameters. In addition to incorporating the expanded ISS treatment area, the fate and transport modeling parameters evaluated within the SWBZ and IWBZ included:

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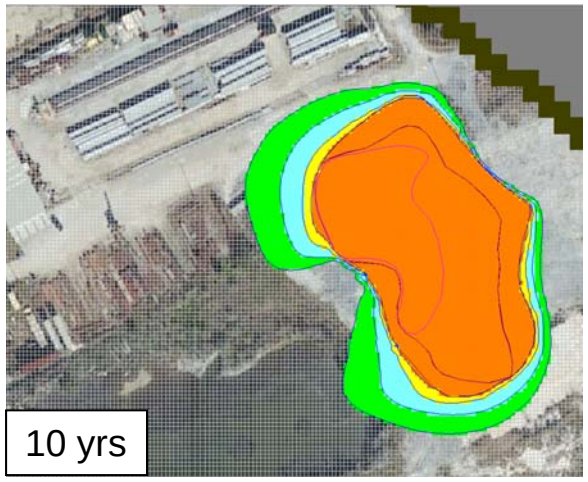
Continued…

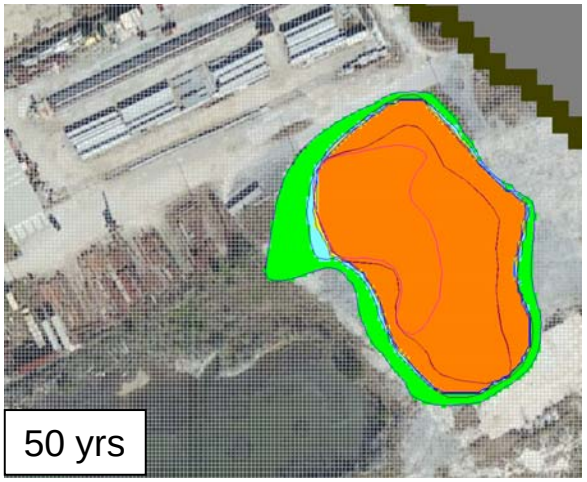
Initial benzene concentration (ppb):	1,000 and 500 ppb
Benzene degradation (half-life, days):	120 and 210
ISS zone hydraulic conductivity (cm/s):	$1x10^{-6}$, $5x10^{-7}$, $1x10^{-7}$
Mass transfer coefficient (1/day):	$5x10^{-12}$ to $5x10^{-7}$
Longitudinal dispersivity:	1, 10, 30, 50

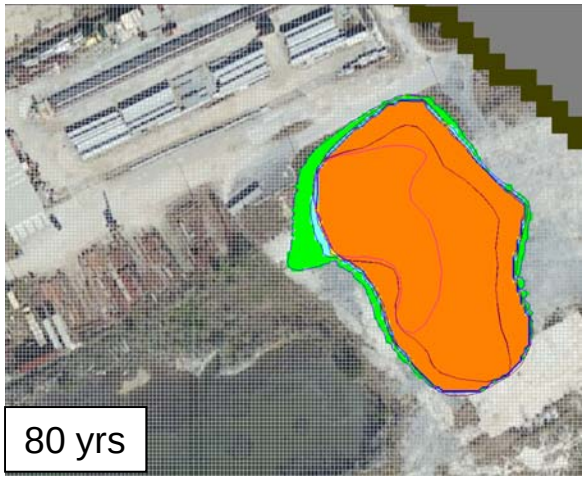
Of note, the original longitudinal dispersivity used in the TIWDR model was 1 foot. This is an extremely conservative (unreasonable) assumption, in that accepted EPA references (Newell et. al., 1996. BIOSCREEN, Natural Attenuation Decision Support System, User's Manual, Version 1.3. EPA/600/R-96/087; Wiedemeier et al., 1999. Technical protocol for implementing intrinsic remediation with long-term monitoring for natural attenuation of fuel contamination dissolved in groundwater, Volume 1, AFCEE, Brooks AFB, TX) would result in acceptable longitudinal dispersivity values of up to more than 180 feet based on suggested equations and general EPA recommendations. Based on the widely accepted rule of thumb cited in these references, the longitudinal dispersivity is 1/10 of the plume length of approximately 300 feet for the SWBZ for this site. The attached supporting documentation provides depicted modeled plumes using longitudinal dispersivity values of 1, 10, 30 and 50 feet in various combinations with other input parameters.

In every modeled scenario, including expanding the ISS treatment zone, reducing the initial source benzene concentrations and adjusting other modeling parameters to test higher and lower values and their various combinations, including longitudinal dispersivity of 1 foot; the fate and transport model indicates a benzene 'halo' continues to exist outside of the ISS treatment zone for an extended period of time (80 to 100 years). The extent of the 'halo' is dependent on the modeled input parameters but ranges from greater than 20 feet to greater than 100 feet downgradient of the ISS treatment zone.

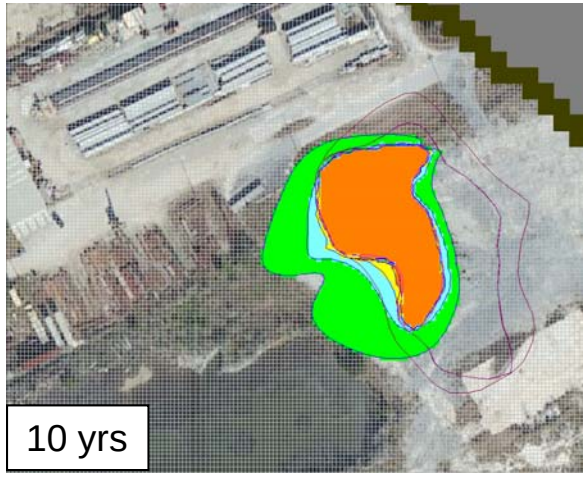
We believe that the information provided in the TIWDR and follow-up communication, including the fate and transport model representations provided herein, conclusively establishes the appropriateness of a Technical Impracticability Waiver for the former Koppers Charleston, SC NPL site.

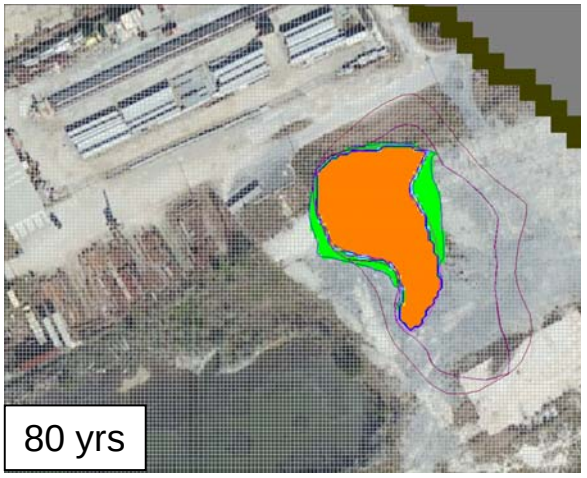




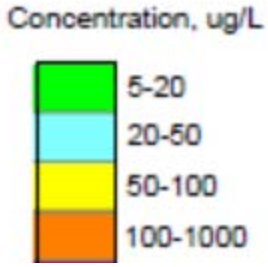


Layer 1, Shallow Zone

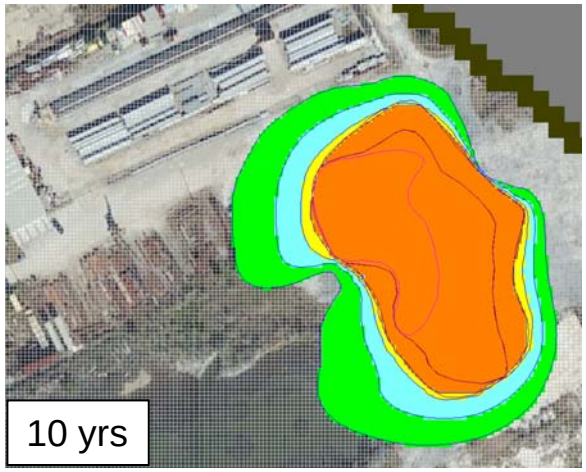


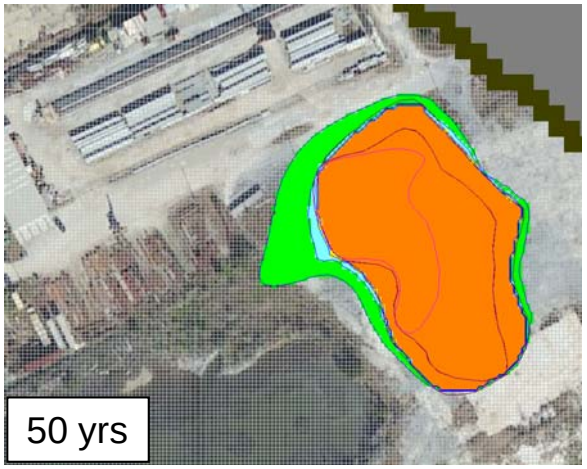


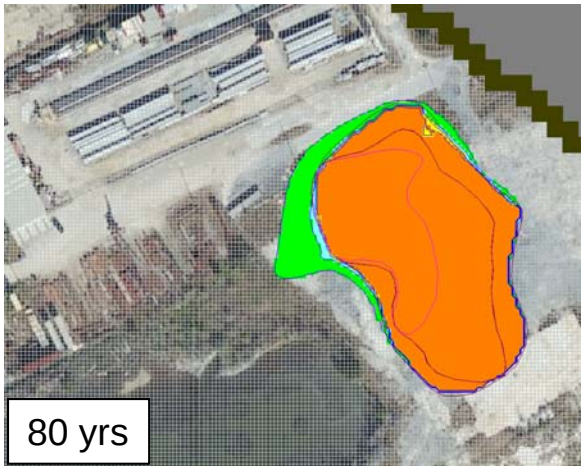
Layer 3, Intermediate Zone



Initial Concentration: 500 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 10







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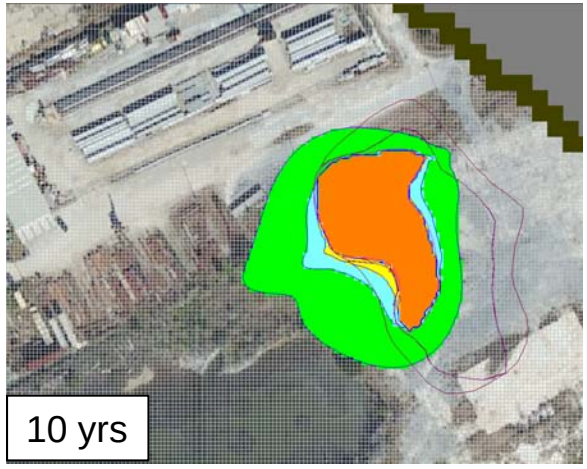
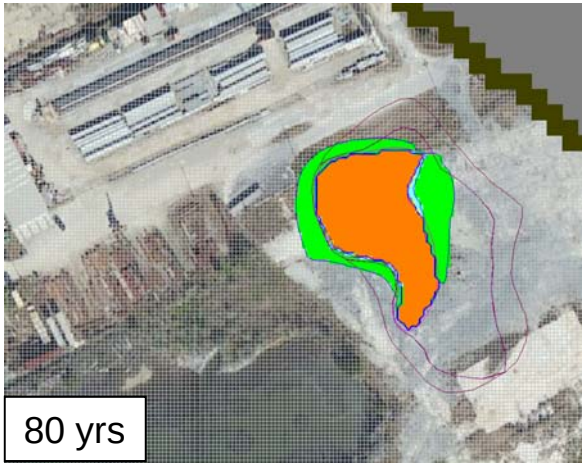
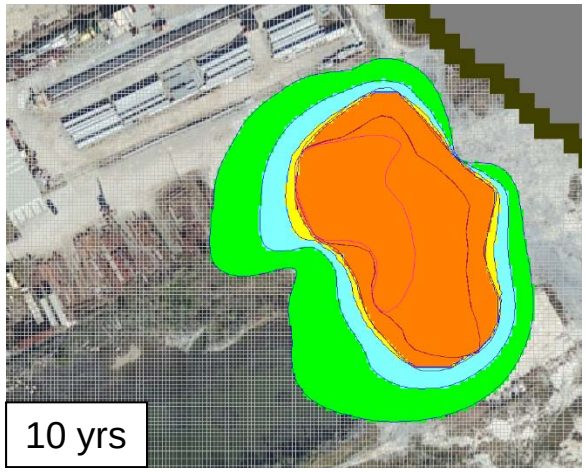
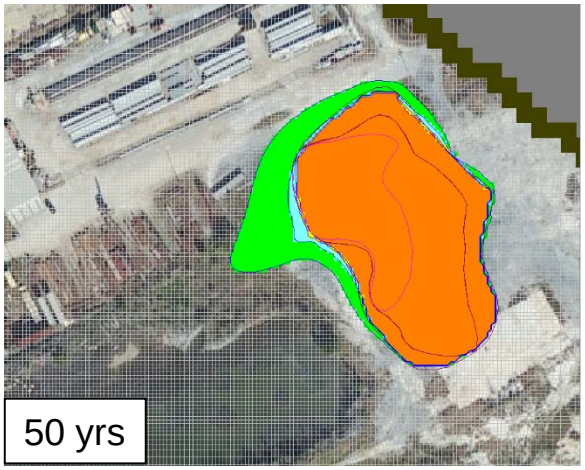


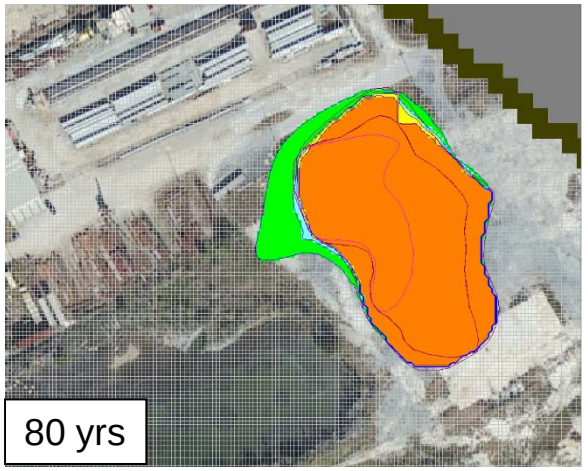


Layer 3, Intermediate Zone

Initial Concentration: 500 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 30







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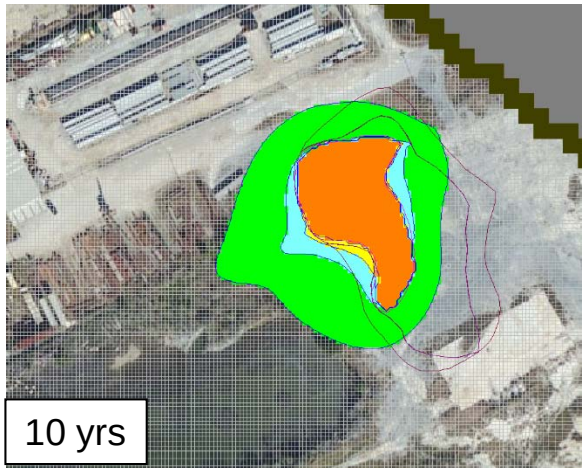
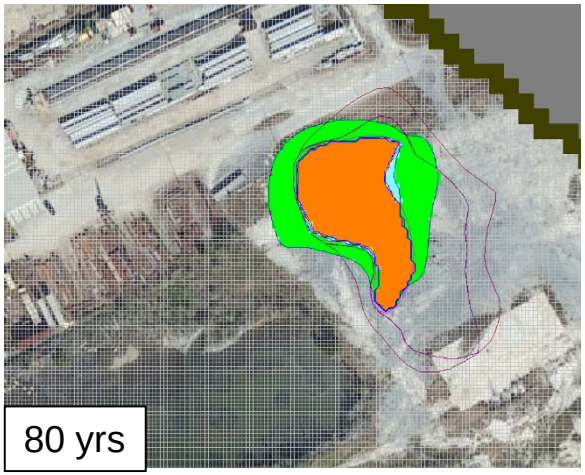
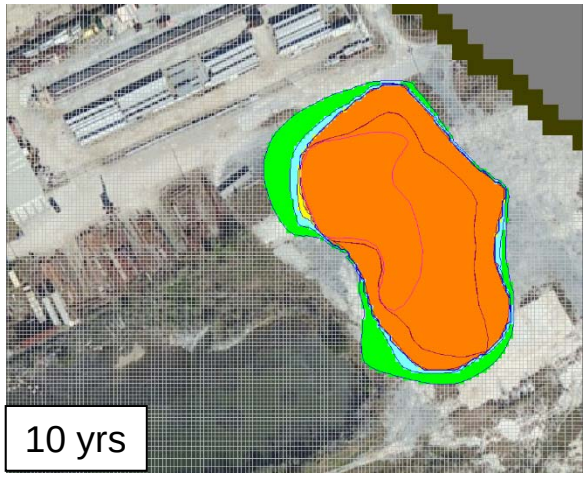
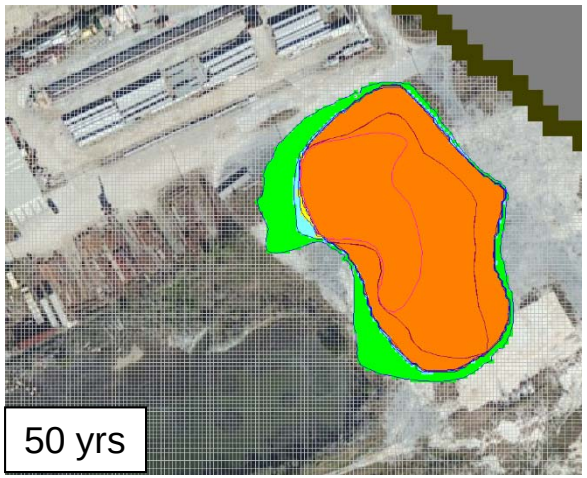


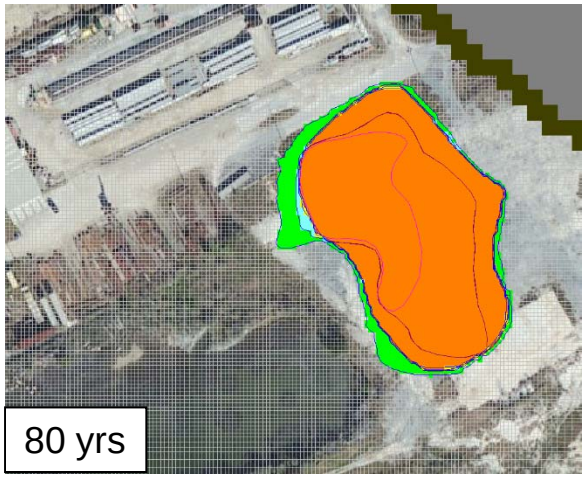


Layer 3, Intermediate Zone

Initial Concentration: 500 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 50







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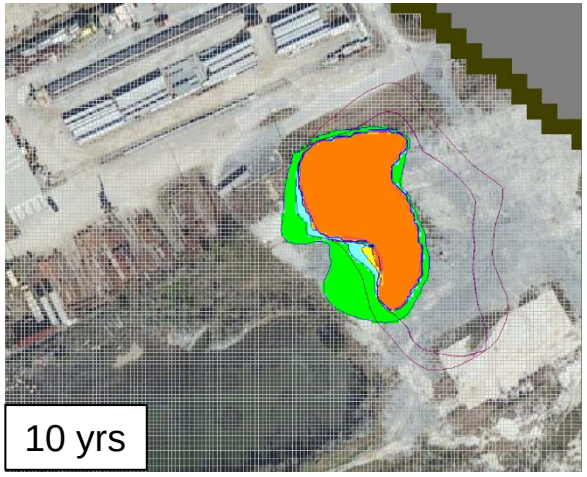
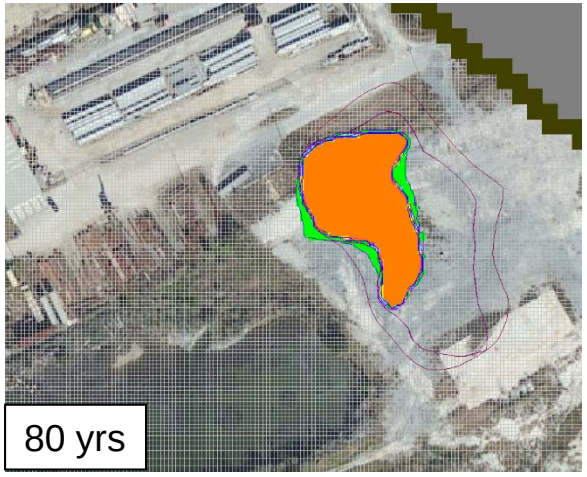
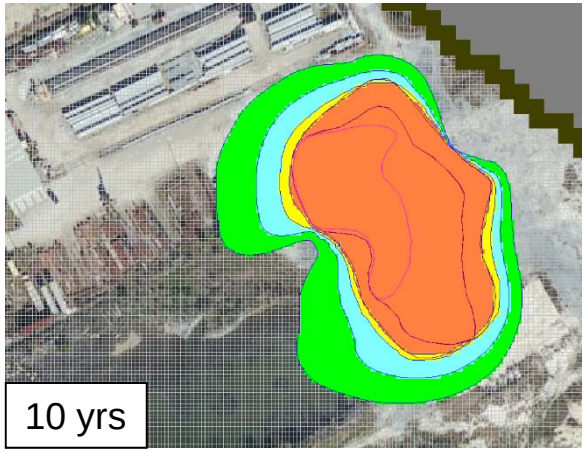


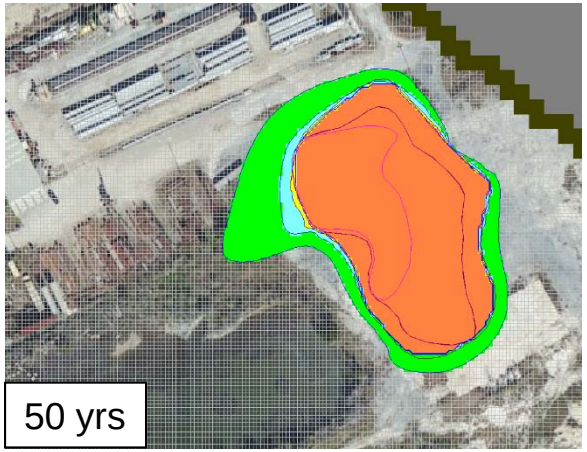


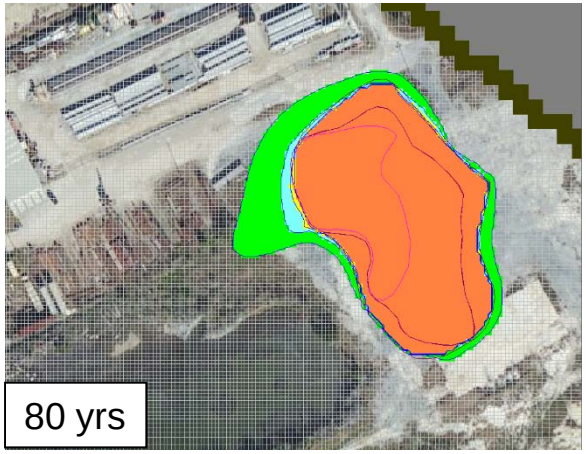
Layer 3, Intermediate Zone

Note:
most unreasonable
of all runs (compounded
unreasonable assumptions)

Initial Concentration: 500 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 1







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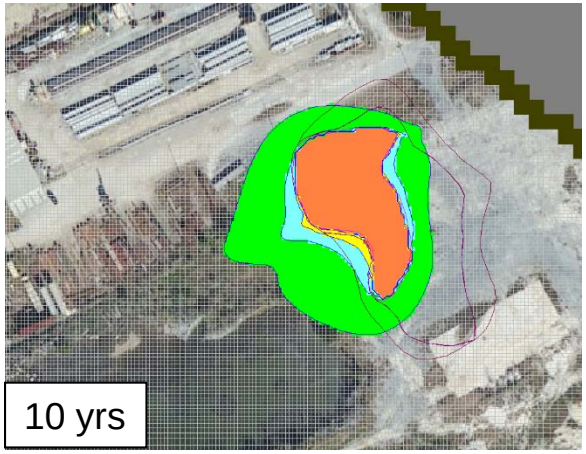
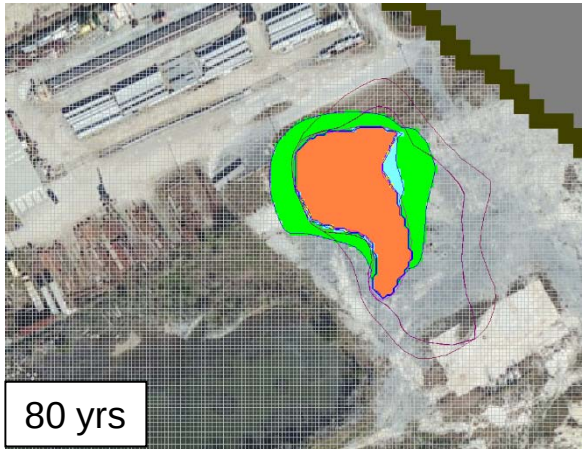
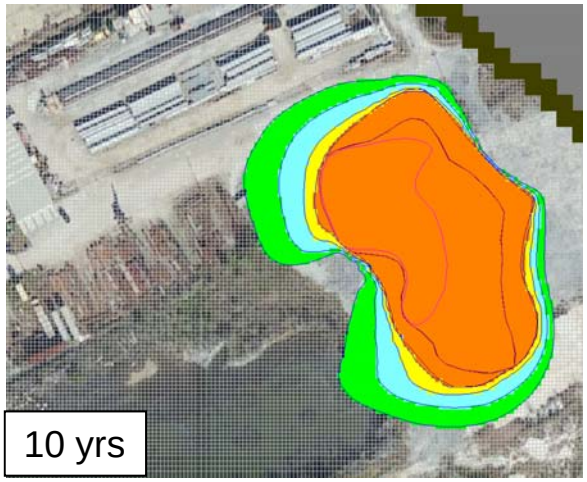
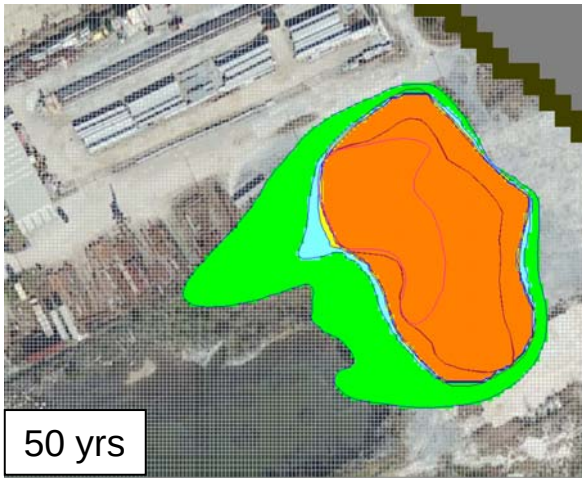


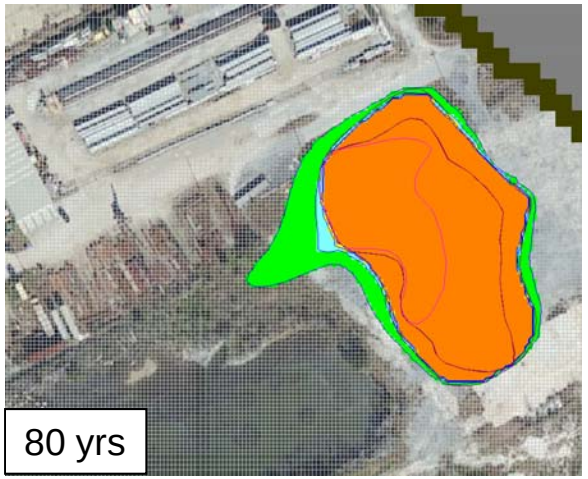


Layer 3, Intermediate Zone

Initial Concentration: 500 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-7}$ 1/d
Longitudinal dispersivity: 30







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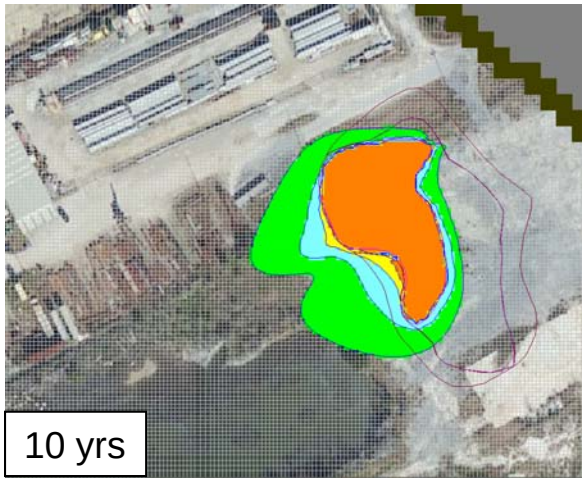
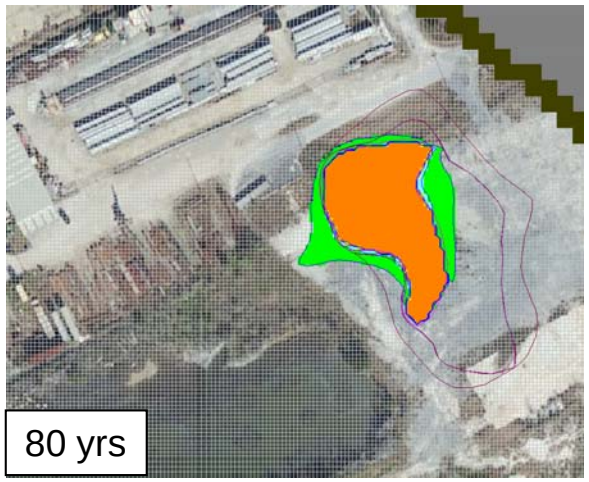
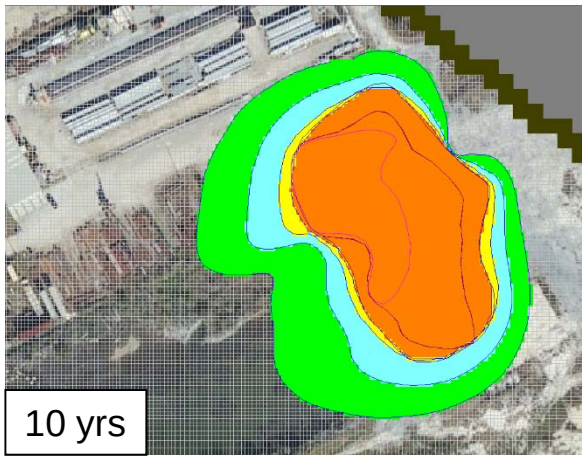
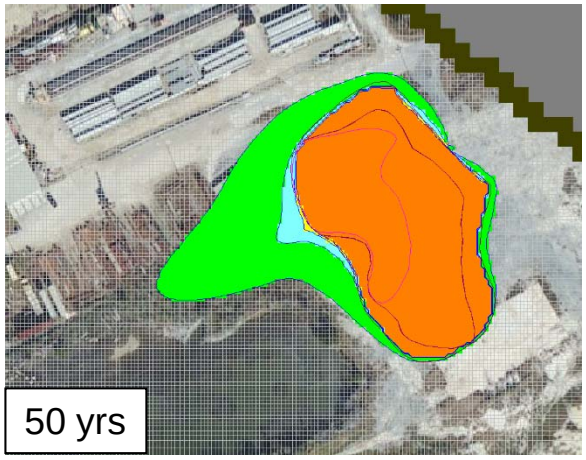


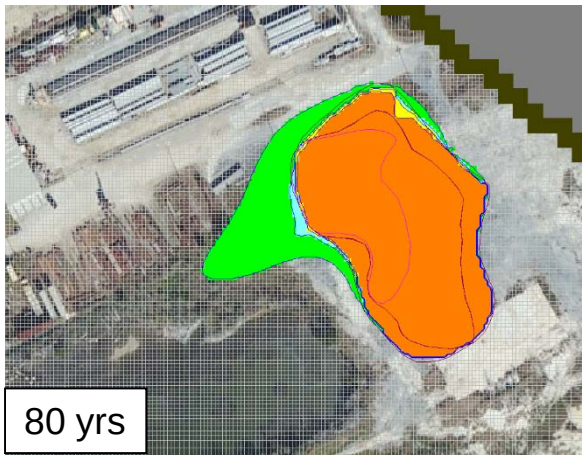


Layer 3, Intermediate Zone

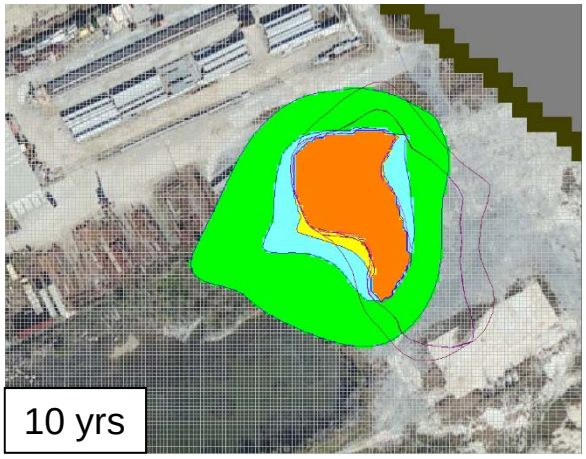
Initial Concentration:	500 ug/L
Benzene half-life:	210 days
ISS Hydraulic conductivity:	10^{-7} cm/s
Mass transfer coefficient:	$5x10^{-12}$ 1/d
Longitudinal dispersivity:	10

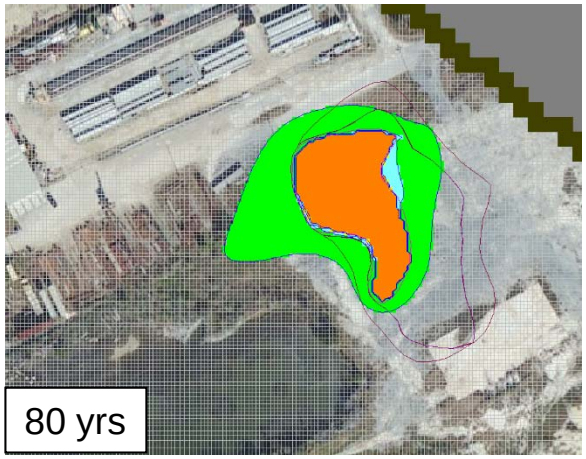






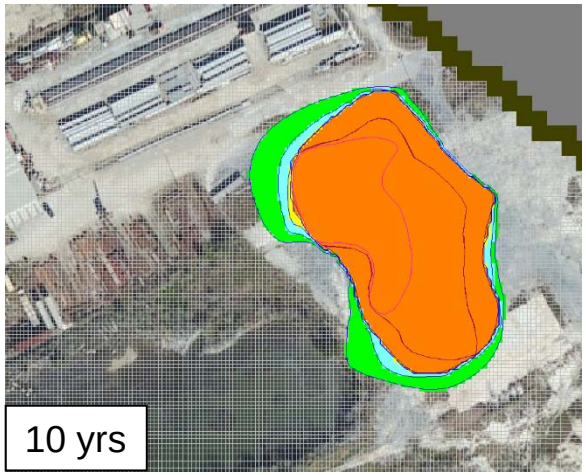
Layer 1, Shallow Zone

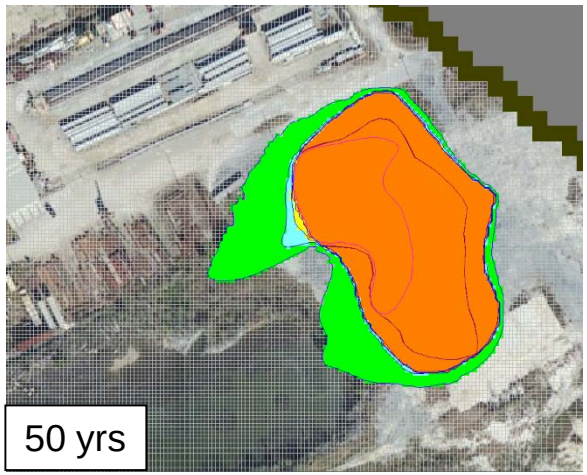


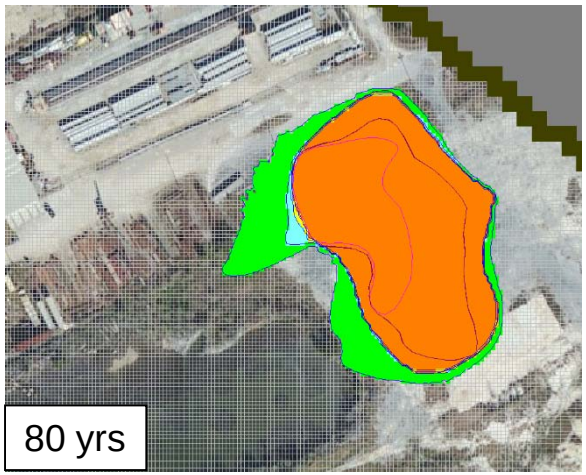


Layer 3, Intermediate Zone

Initial Concentration: 500 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 50







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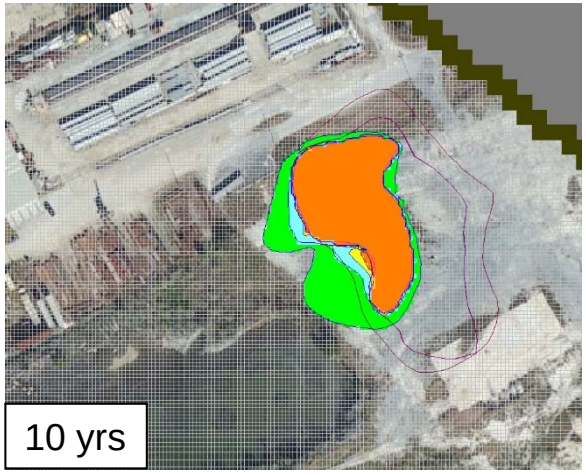

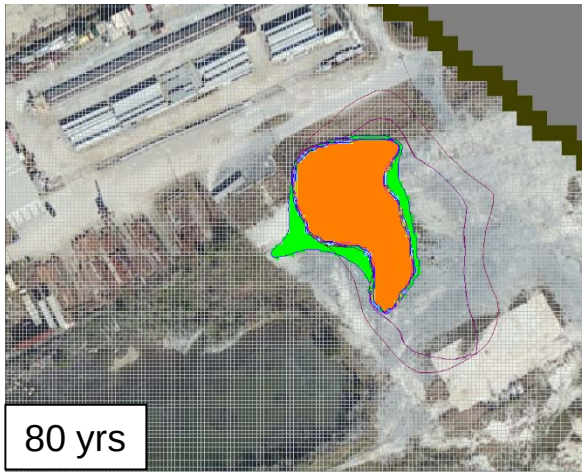

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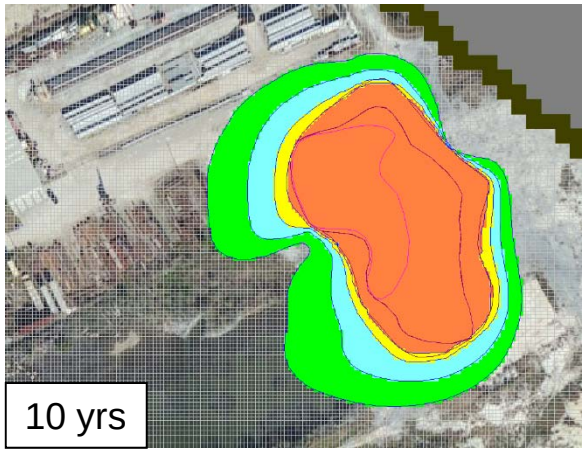
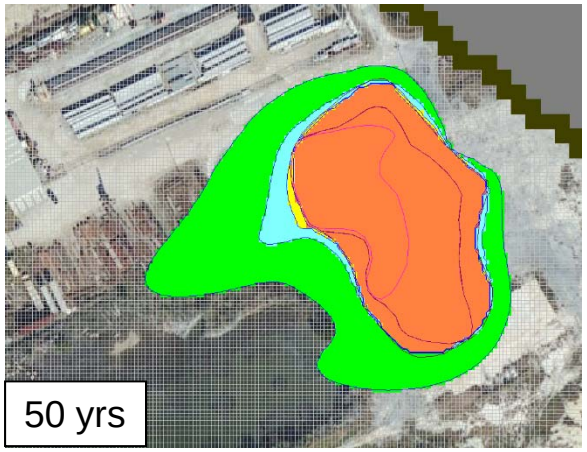
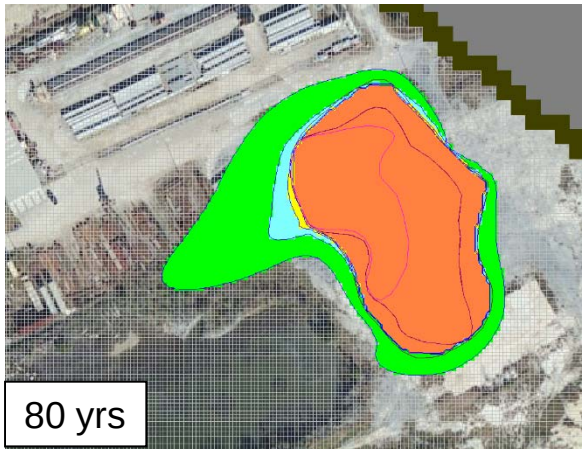
Initial Concentration: 500 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 1







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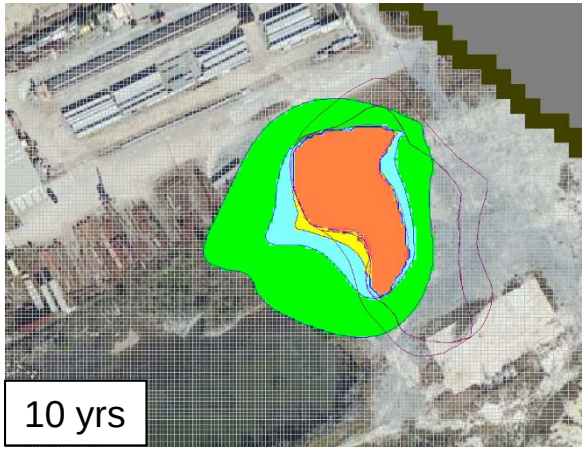
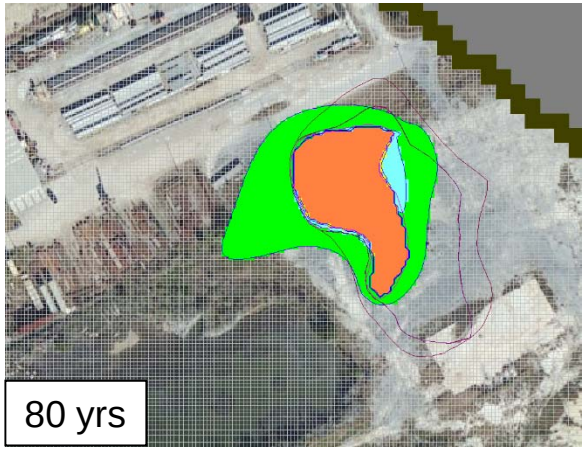
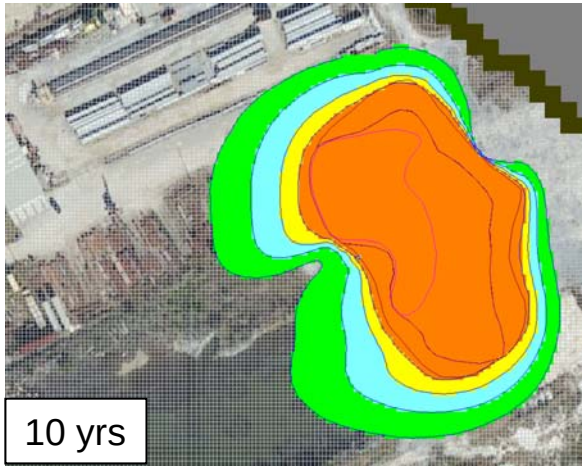
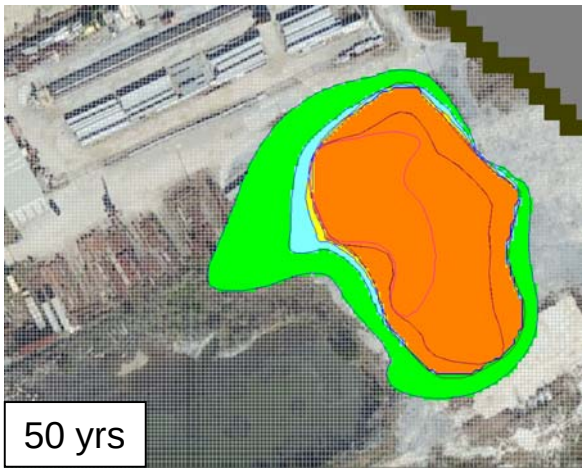


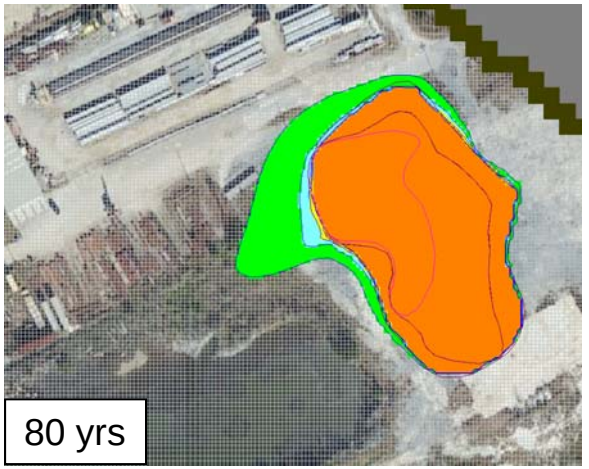


Layer 3, Intermediate Zone

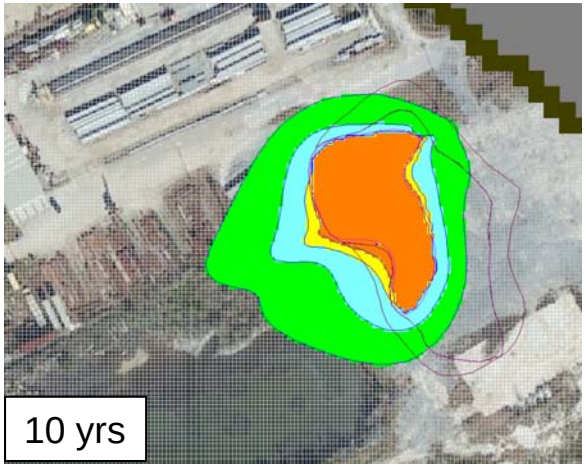
Initial Concentration: 500 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-7}$ 1/d
Longitudinal dispersivity: 30

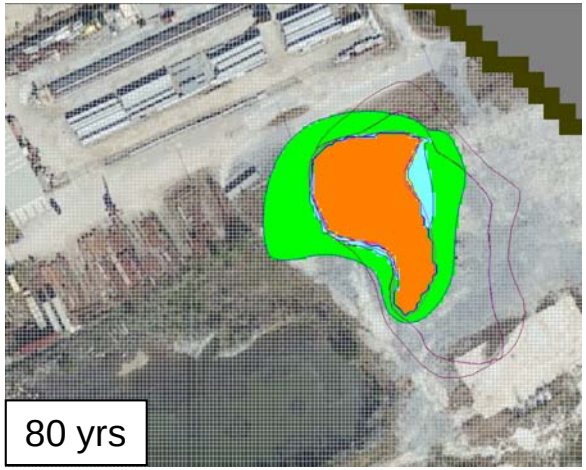






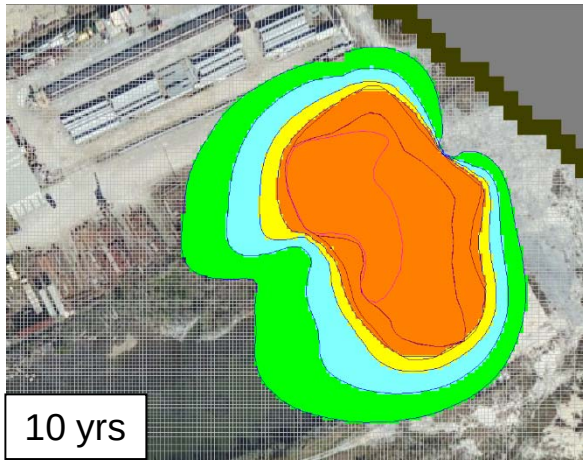
Layer 1, Shallow Zone

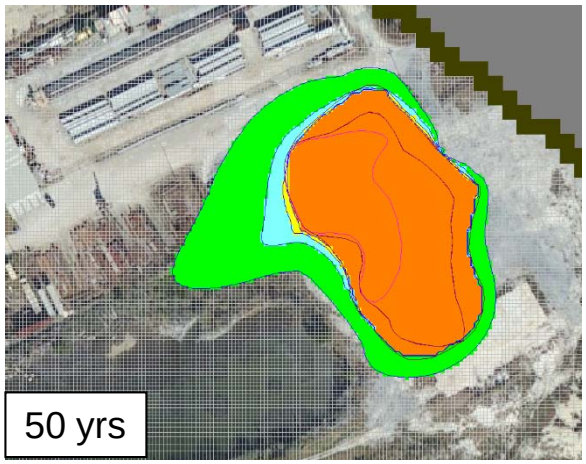


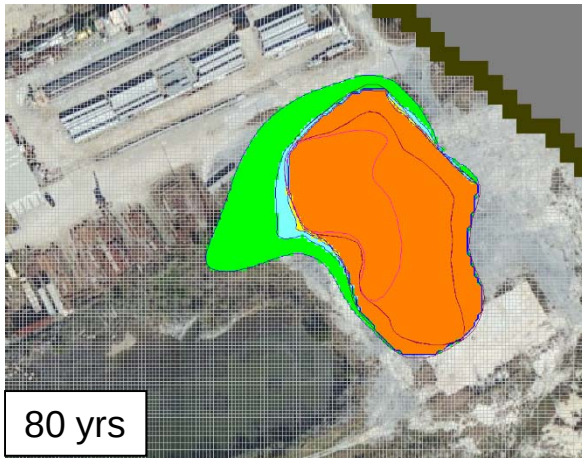


Layer 3, Intermediate Zone

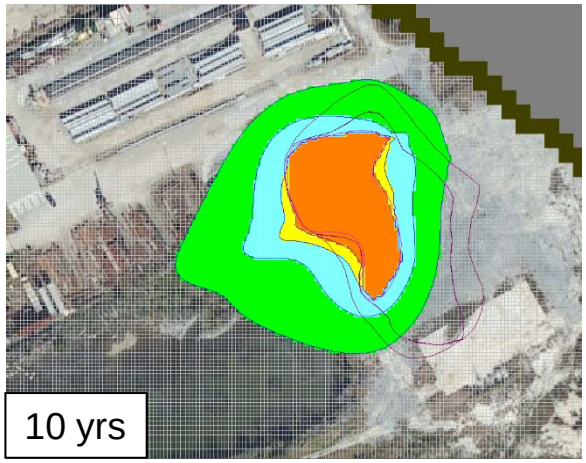
Initial Concentration:	1000 ug/L
Benzene half-life:	120 days
ISS Hydraulic conductivity:	10^{-7} cm/s
Mass transfer coefficient:	$5x10^{-12}$ 1/d
Longitudinal dispersivity:	30

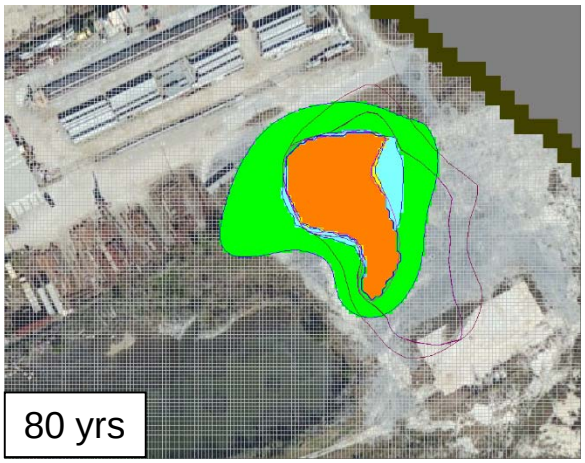






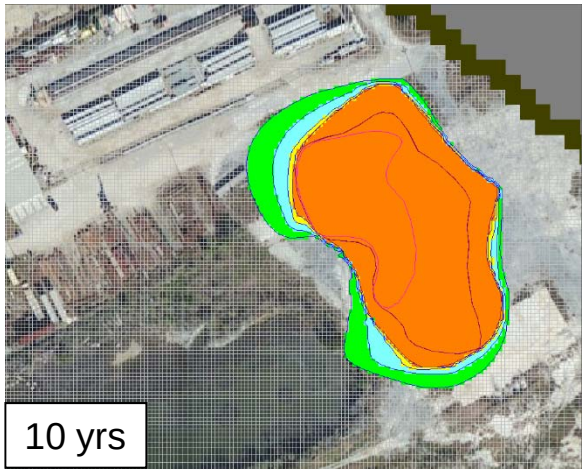
Layer 1, Shallow Zone

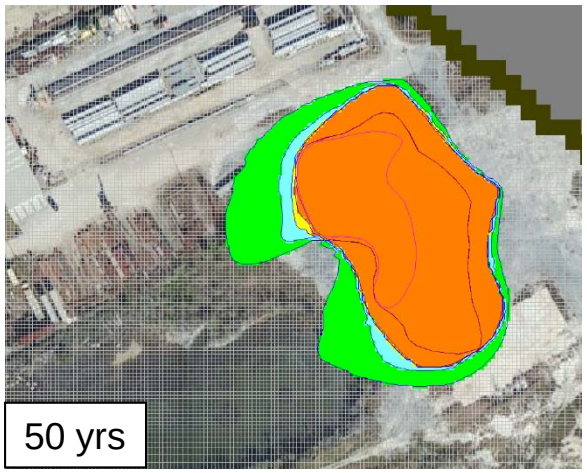


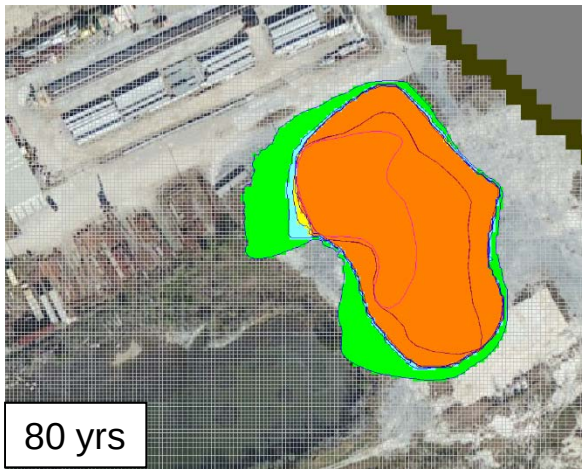


Layer 3, Intermediate Zone

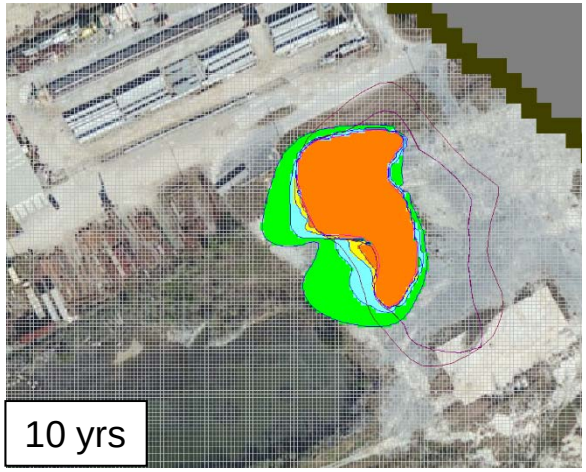
Initial Concentration: 1000 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 50

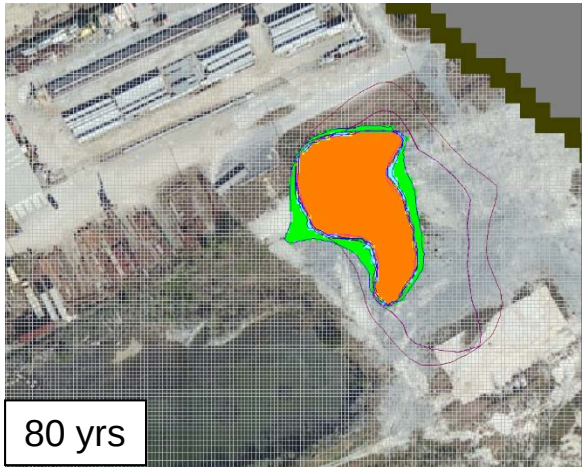






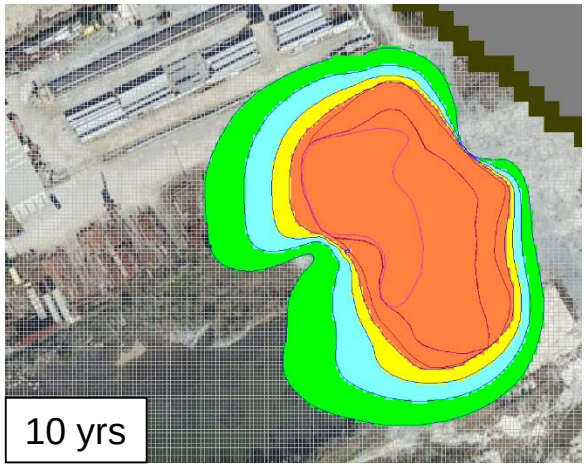
Layer 1, Shallow Zone

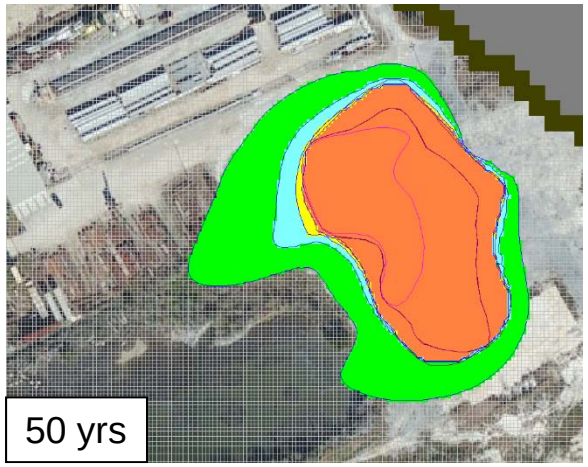


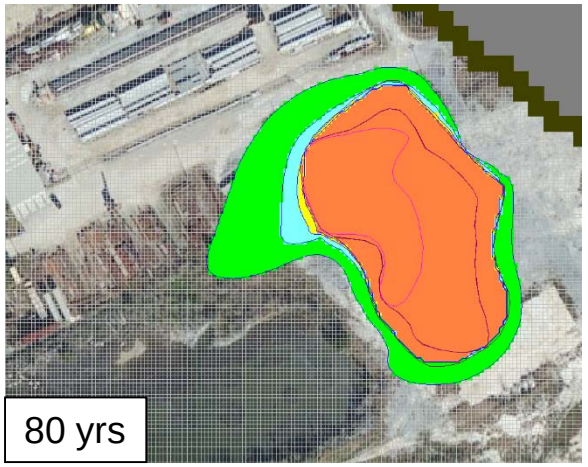


Layer 3, Intermediate Zone

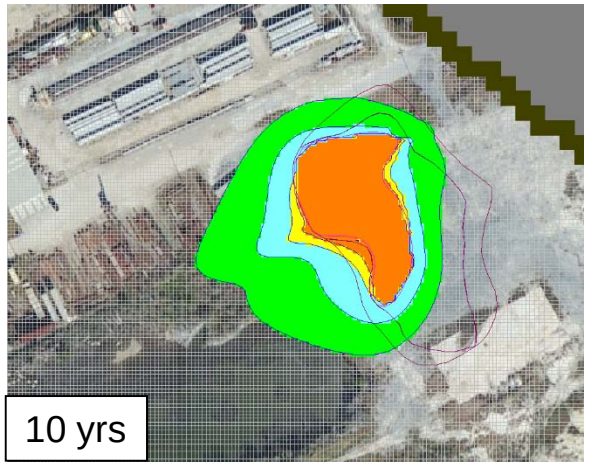
Initial Concentration: 1000 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 1

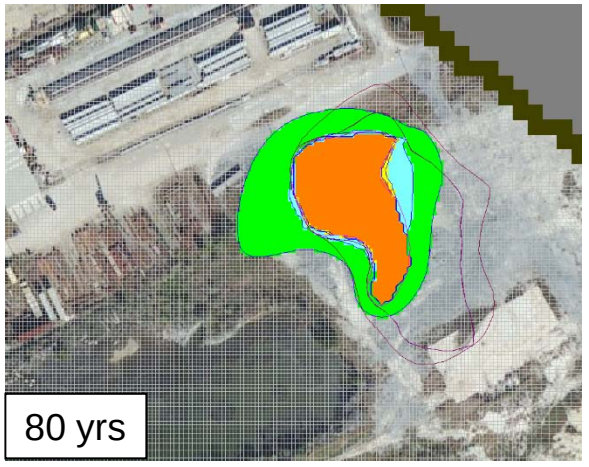






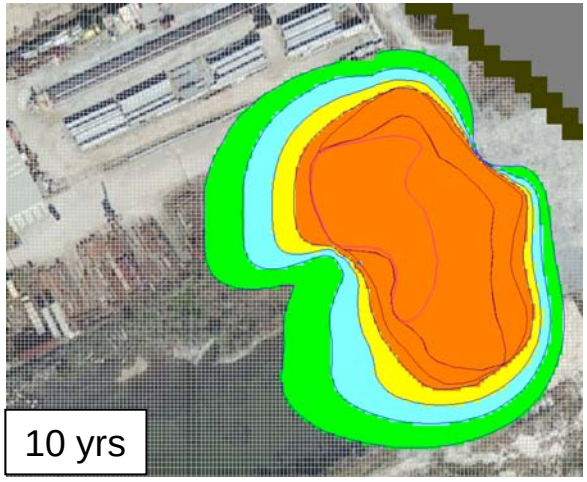
Layer 1, Shallow Zone

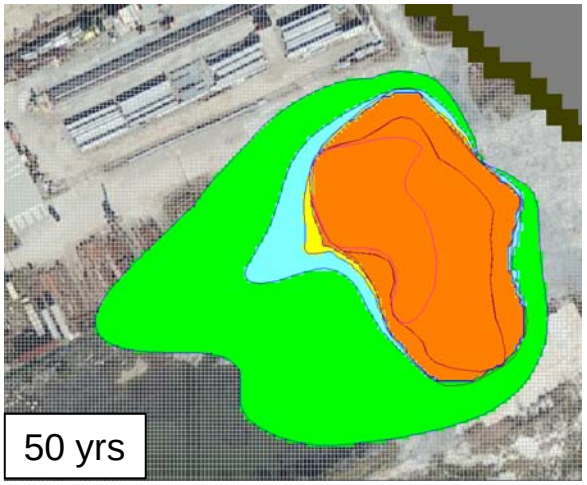


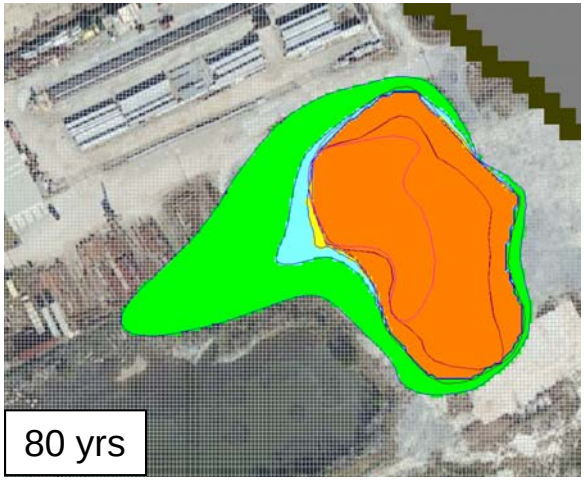


Layer 3, Intermediate Zone

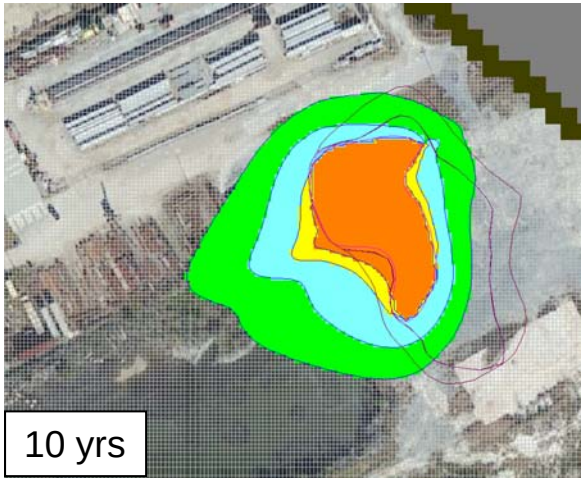
Initial Concentration: 1000 ug/L
Benzene half-life: 120 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-7}$ 1/d
Longitudinal dispersivity: 30

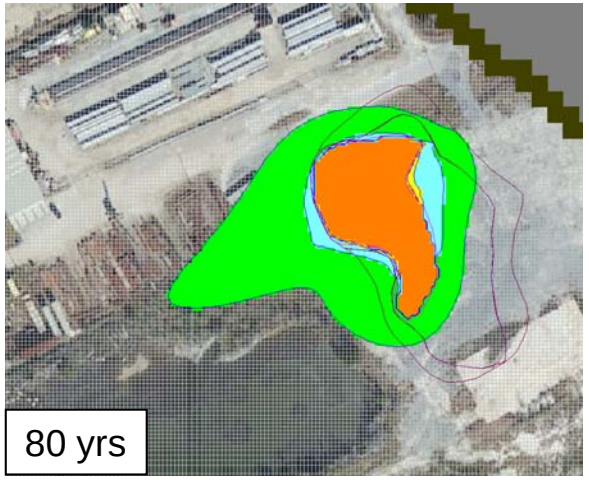






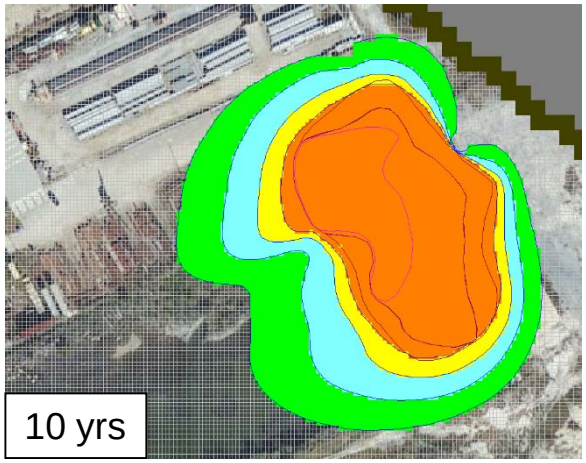
Layer 1, Shallow Zone

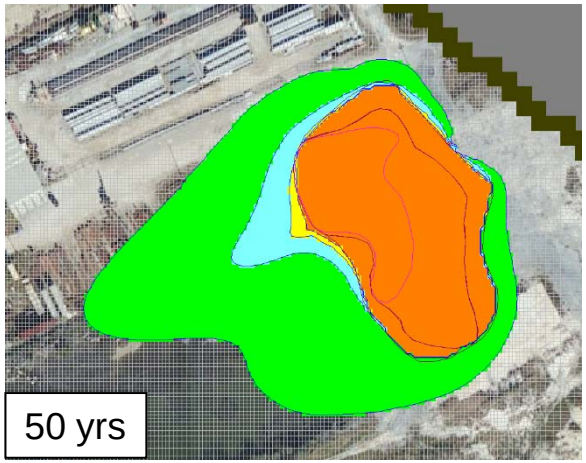


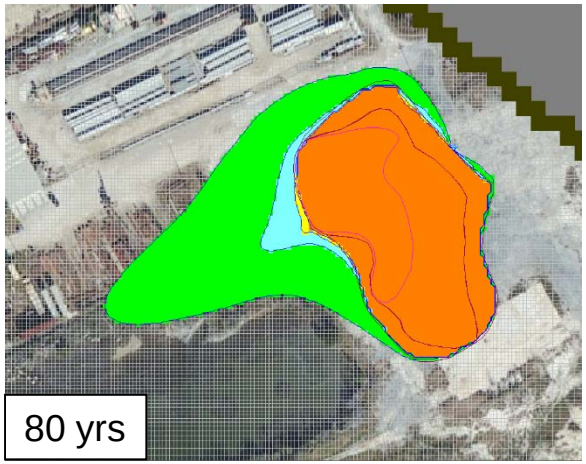


Layer 3, Intermediate Zone

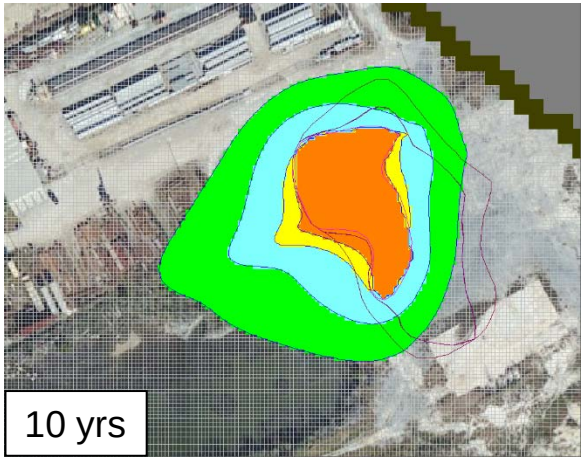
Initial Concentration: 1000 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 30

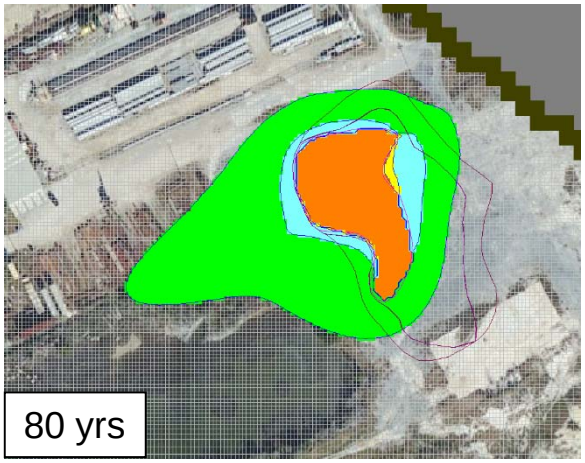






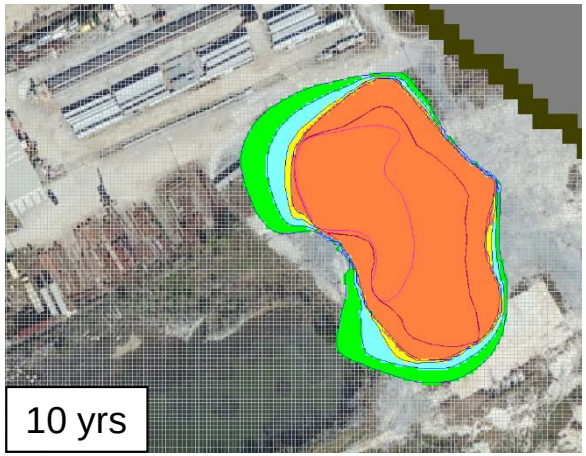
Layer 1, Shallow Zone

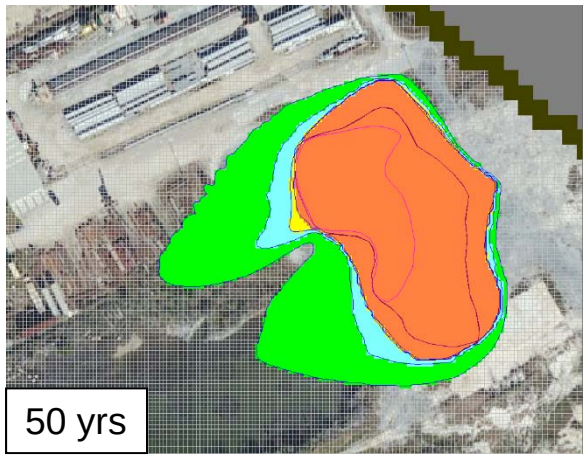


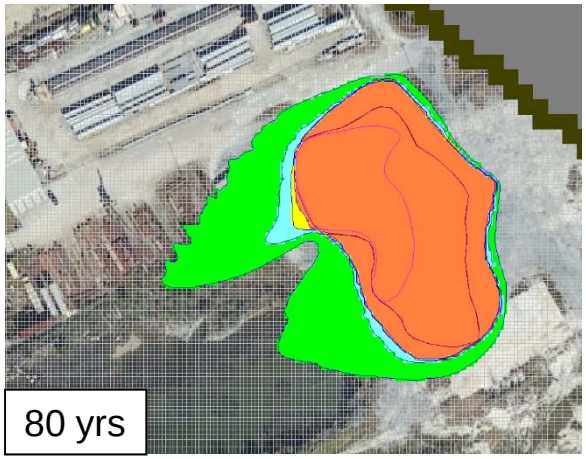


Layer 3, Intermediate Zone

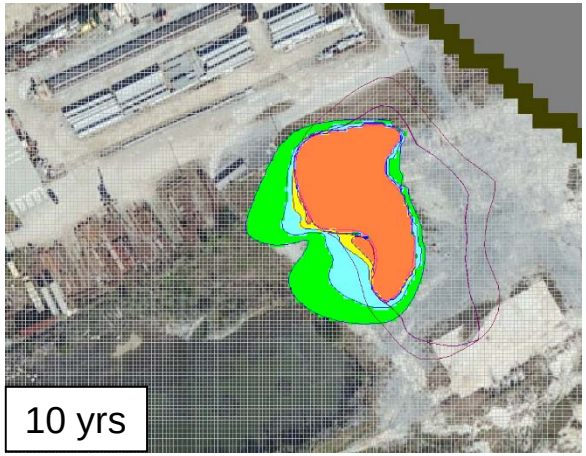
Initial Concentration: 1000 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 50

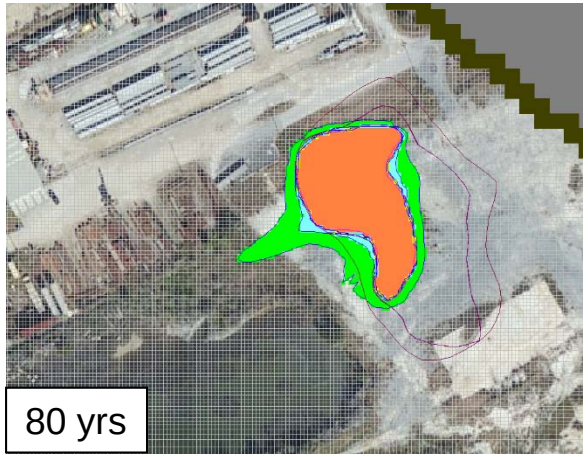






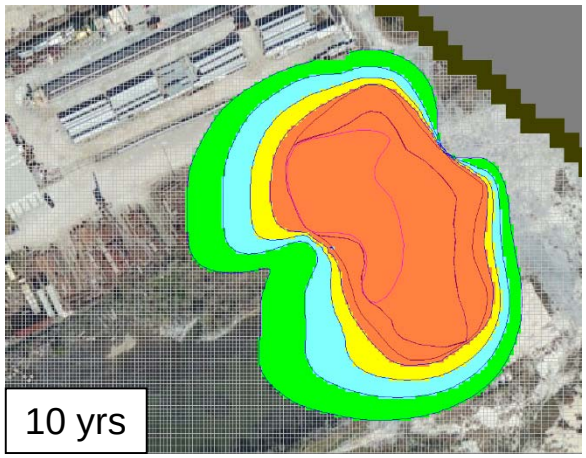
Layer 1, Shallow Zone

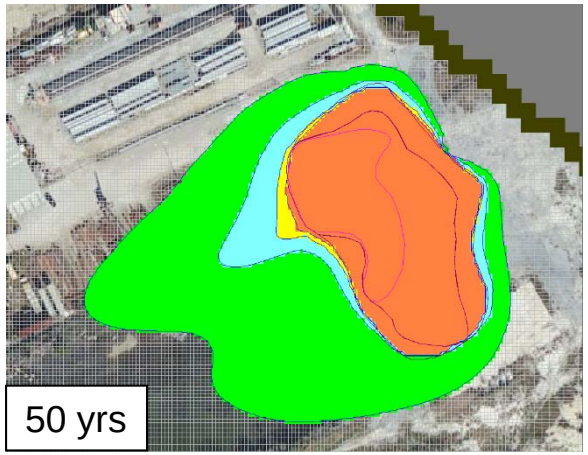


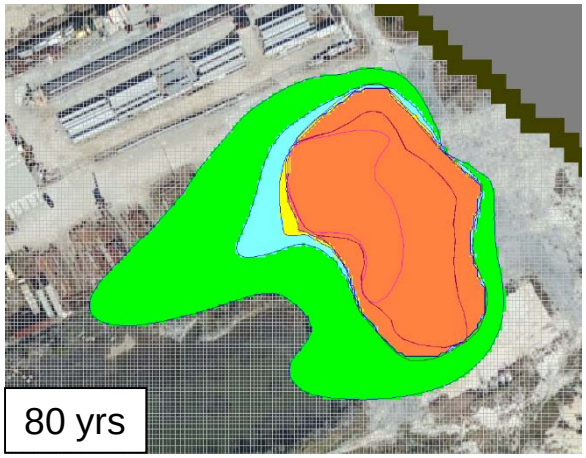


Layer 3, Intermediate Zone

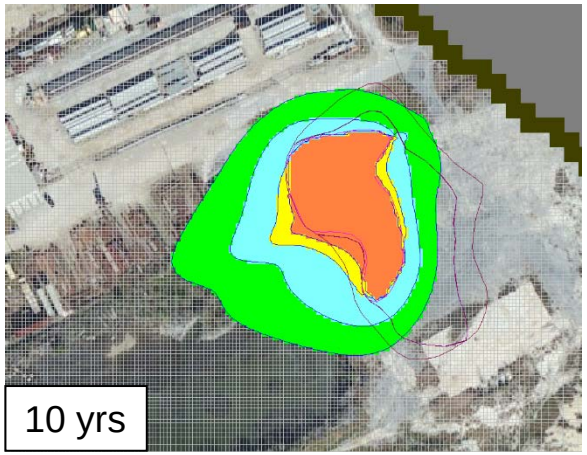
Initial Concentration: 1000 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-12}$ 1/d
Longitudinal dispersivity: 1

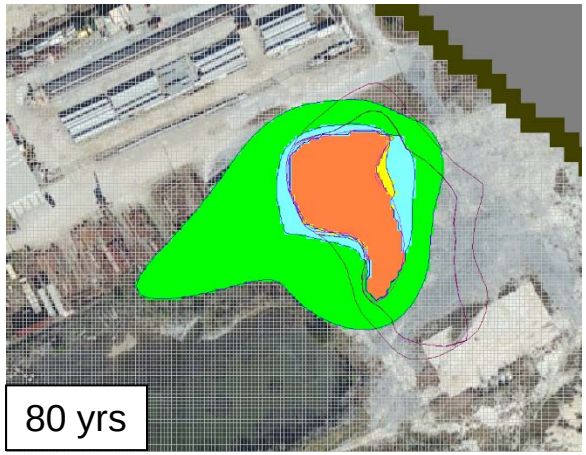






Layer 1, Shallow Zone





Layer 3, Intermediate Zone

Initial Concentration: 1000 ug/L
Benzene half-life: 210 days
ISS Hydraulic conductivity: 10^{-7} cm/s
Mass transfer coefficient: $5x10^{-7}$ 1/d
Longitudinal dispersivity: 30